Research Horizons Day
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COLLEGE OF ENGINEERING
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Research Horizons Day

Wearable Sensor Network of Inertial Measurement Units to Track, Classify, and Assess Performance of Complex Body Motions

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Overview

A wearable sensor network (WSN), also known as a wireless body area network (WBAN), of multiple 9 degrees of freedom (9DOF) Inertial Measurement Unit (IMU) motion sensors is capable of capturing and processing movement data in a variety of environments.

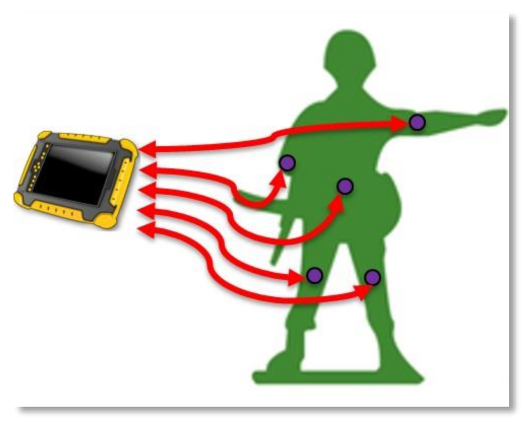

Figure 1. Wearable Sensor Network

Current sports technology utilizes a primary sensor augmented with specialized remote sensors for general location information, swimming stroke cadence, cycling wheel and pedal cadence, and running cadence. My early investigation uses cycling in context of triathlon.

IMU motion sensors using microelectromechanical systems (MEMS) technology are capable of supporting data collection and analysis orders of magnitude beyond current commercialized technology.

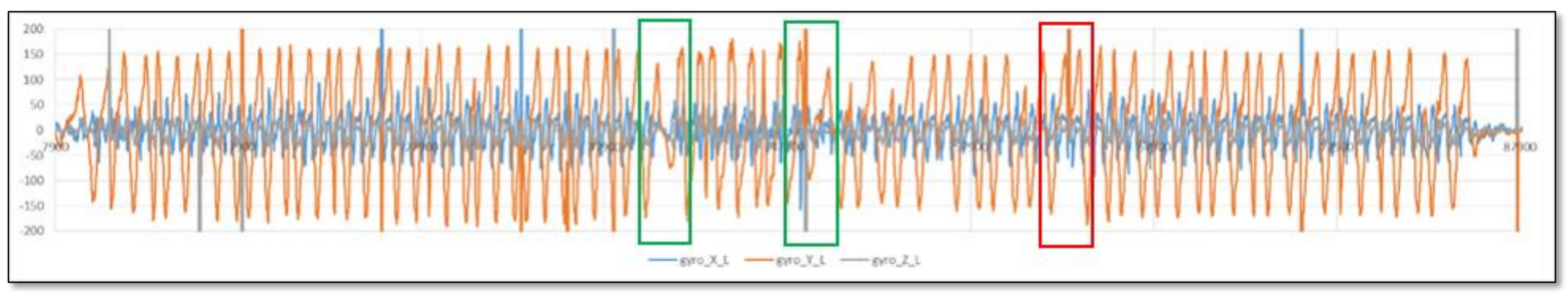

Figure 2. Discriminating Motion of Body Worn 9DOF Sensors While Cycling

My research focus area is developing wearable sensors capable of collecting high fidelity, high sample rate, 9DOF motion data with sufficient processing power to perform real-time human activity recognition and task performance assessment for sports, medical, and military applications.

Impact

Automating human activity recognition enables self-coached athletes, medical assessments in austere environments, and deep learning of complex body motions over multiple sampling sessions. For example, the Instrumented Stand-up and Walk (ISAW) assesses mild traumatic brain injuries and informs a return to duty decision with increased confidence with prior and post event data to compare.

Figure 3. Garmin FR60 and Cycling Kit augmented with Wireless Sensors

Multiple sensors enables symmetry comparisons and detailed body segment analysis. A data collection system capable of collecting high fidelity, high sample rate data over multiple sessions enables real-time assessment of fitness and fatigue, forecast recovery, predict injury, and manage expectations for performance improvement.

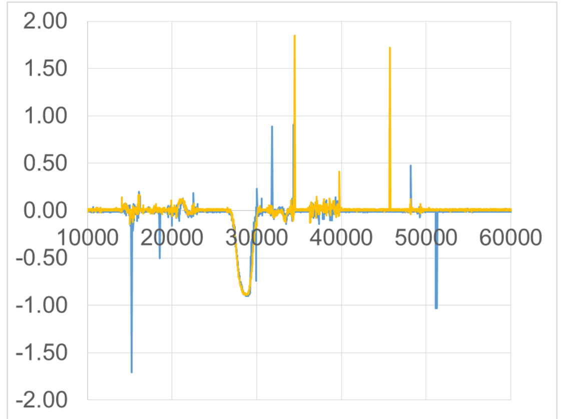

Figure 4. Pedaling Symmetry Check

Acknowledgements

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Explanation

A 9DOF motion sensor includes an accelerometer, gyroscope, and compass to measure acceleration, rotation, and magnetism in three axis each. Acceleration is integrated across measurements for velocity and position. Earth's gravitational and magnetic forces assist in developing a reference frame. The motion sensor is supported by a microcontroller, battery, data storage, and communications.

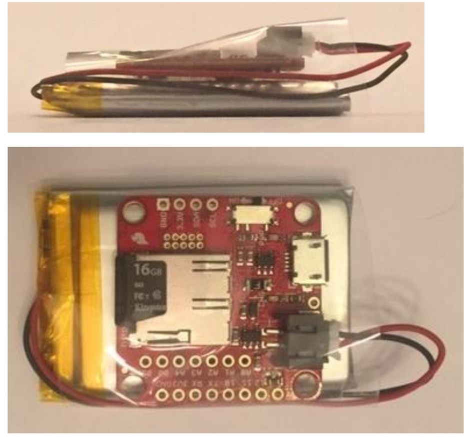

Figure 5. Sensor consisting of Motion Sensor, 16 GB SanDisk, and 1mAH Battery

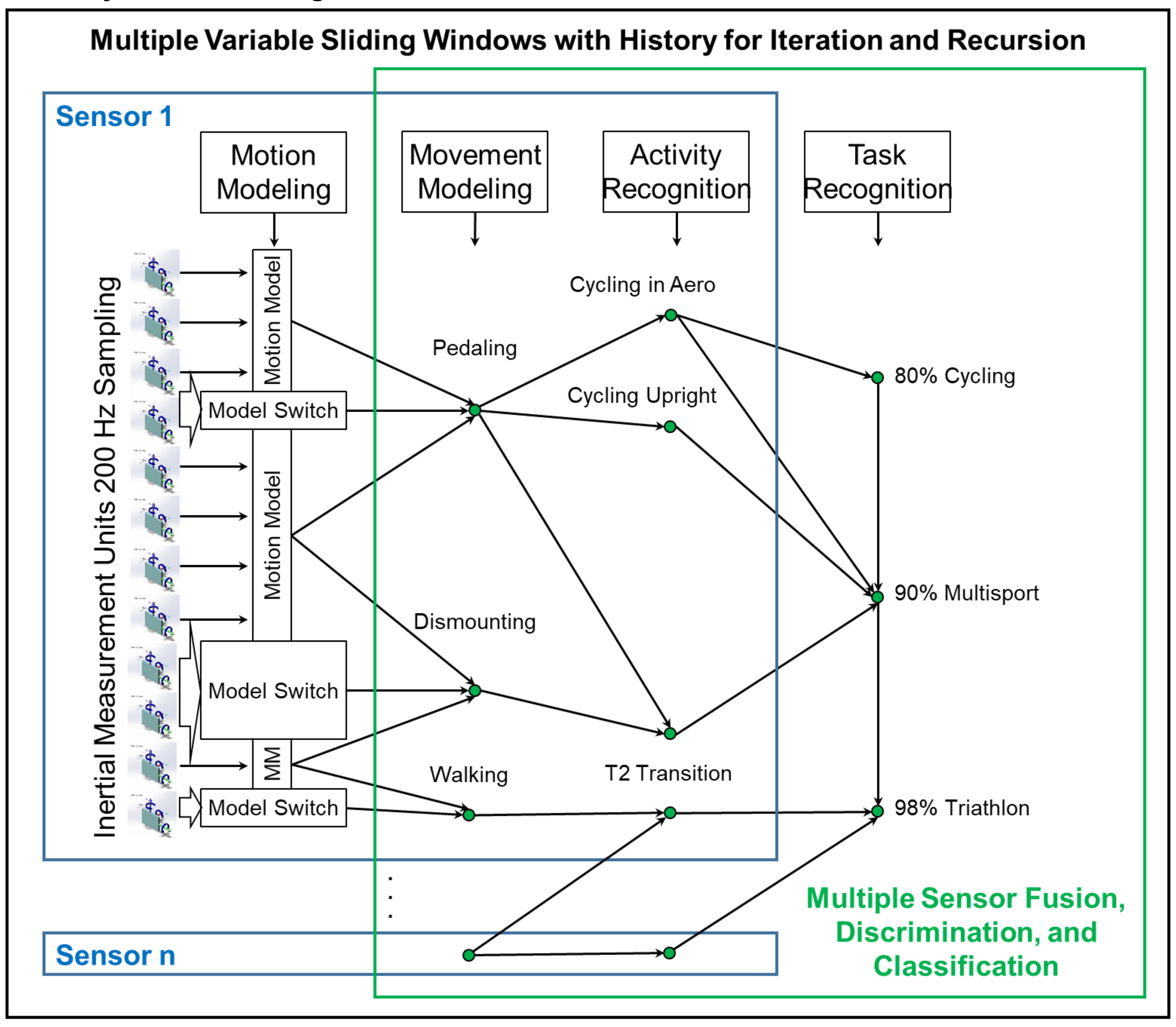

Figure 6. Multiple Sensors Tracking, Classifying, and Assessing Tasks

Key Findings and Way Ahead

Existing solutions are insufficient for operating in austere environments, only provide a few real-time metrics, and perform detailed data processing and analysis offline. Initial concept development and motion sensor analysis of multisport activities shows promise for expanding to medical quality data collection and real-time complex body motion task analysis. Advances in motion sensor, data storage, and power technology enable a significant form factor reduction and processing improvement which along with 3D printing provides a ruggedized, human adaptable, and scalable set of sensors.

Future work is focused on the transition of current centralized offline solutions to a real-time distributed wearable processing architecture using lower power, higher fidelity, higher sample rate motion sensors. Sports enthusiasts and medical practitioners need real-time feedback taking into consideration human subjects performance over extended periods of time.

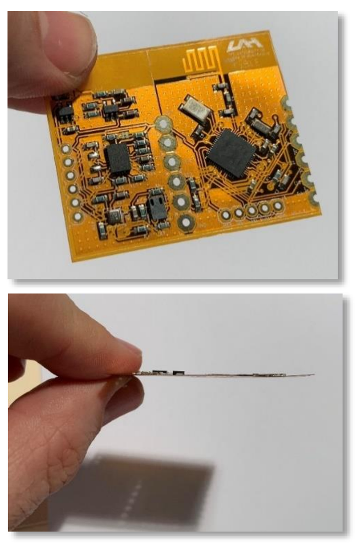

Figure 7. UAH Sensor

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Figure 8. Audio Feedback